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THE FORMATION AND DEFORMATION OF MINNESOTA LAKES.

BY C. W. HALL, MINNEAPOLIS, MINNESOTA.

IN respect to inland waters Minnesota shows conditions which are exceptional in North America. Exclusive of that portion of Lake Superior within her boundary, the State has 5,700 square miles of lakes varying from a few acres to the size of Red Lake, which has 340,000 acres in its area. These lakes are conveniently divided into three classes.

First, rock-bound lakes. These bodies of water occur chiefly in the northeastern portion of the State. They occupy the troughs in the crustal folds that have contorted the surface, or the depressions where excessive faults have broken and considerably tilted the strata. These, as a rule, are long, narrow, and deep. The water is clear and sparkling, abounding in fish, and remarkably free from the various forms of plant growth peculiar to shallow waters.

Second, silted-river lakes. These lakes occur in rivers where rapid streams have brought down a deposit into the channels of the more sluggish ones, the silting debris being so course that the slower current fails to transport it. Thus slower streams are choked up and the water set back for miles. Such lakes are Lake Pepin, formed where the sluggish Mississippi is dammed by the debris brought into its channel by the more rapid Chippewa River, Lake Saint Croix, Lake Lac qui Parle, and many others.

Third, glacial lakes. If this group could be minutely subdivided, there would be seen several types of lake formation. Those of the Lake Agassiz type, where one portion of the shore consisted of a wall of ice, have long since disappeared and left scattered pools of varying sizes, occupying the depressions in the generally level surface of the old lake bottom. Going outside of the State for an illustration, we may name Lake Winnipeg as the largest pool now remaining in the bottom of glacial Lake Agassiz. Many other lakes are scattered over the level portions of the State, occupying the depressions in the drift-sheet where this was laid down evenly through the steady and uniform movement of the ice, or through the silting effect of waters due to the melting of the ice border.

But by far the greatest number of lakes in Minnesota are those occupying the depressions in the unevenly distributed morainic matter deposited during glacial times. Portions of the State are thickly studded with these beautiful sheets of clear water. The region between Minneapolis and the Red River valley is appropriately called the Lake Park Region, as lakes occur here in vast numbers. Wright County, nearest to Minneapolis, contains 259 lakes, Kandiyohi County contains 286, and Ottertail County, well up towards the borders of glacial Lake Agassiz, holds the banner over 430 lakes. Passing northeastward from the Lake Park Region towards Ontario, past the head-waters of the Mississippi, and across the upper streams of the St. Lawrence River basin, we pass gradually from the region of moraines to the region of thin glacial deposits and constant and tumultuous rock-exposures, carrying large numbers of lakes of the first type.

It has been frequently estimated that Minnesota contains 10,000 lakes. To one passing over the State through the region named this does not seem an exageration. There must be several thousand lakes from one mile in length upwards to the very largest.

While glacial lakes show many varieties of form due to the position of tongues, branches, and subdivisions of the moraines, they are generally circular in outline. The deepest portion is at the centre. Their shores show but few successive beaches to indicate erosion at their outlets and consequent drainage, or great variation in the amount of rainfall during the last few thousand years. They were all evidently formed in the same general manner, by the washing down of fine silt from the high land into the bottom, thus gradually filling the interstices in the gravels and sands beneath them, making water-tight bottoms to hold the water. Probably the lakes were small at first, and enlarged gradually as this deposition of fine silt extended their borders until the lowest point in the margin was reached and an outlet drained away the excess of water. When this outlet was reached the conditions of formation ceased, and the conditions of deformation became manifest. Material was constantly washing in from the high lands around through the melting snow of successive springs and the heavy showers and rain-storms of the summer months; it was also brought by streams flowing into the lakes from every direction, and formed *in situ* by the vigorous growth of aquatic vegetation. In the shallower lakes this last cause of deformation works with great rapidity. After the ice disappears in the spring under the warm sun of this latitude the water very rapidly rises in temperature to 70° or 75°, a favorable temperature for vigorous vegetable growth, and thus plant-forms which can get foothold upon the lake bottom will develop a vast amount of plant debris. Already hundreds of the shallow, small lakes of the State have disappeared, and rich, productive hay-meadows have taken their place. This will be the fate of thousands more within the coming century. On every hand we hear old settlers speak of large lakes once affording superb hunting ground for wild geese, ducks, and other water fowl and excellent fishing, as now either hay-meadows or extensive marshes soon to be fitted for hay production by a further lifting of the surface above the level of the outlet through this rapid accumulation of the vegetable mold.

The lakes of Minnesota afford some of the most attractive summer resorts to be found in our northern States; as already famous can be mentioned Minnetonka, White Bear, the Chisago Lakes, and Waconia. The list can be indefinitely extended. Their climatic influence is very marked. The amount of heat stored up during the summer, if calculated by its mechanical equivalent, is enormous. With 43° as the average increment in temperature, 10 feet as an average depth of 5,700 square miles of water surface, we have nearly 11 cubic miles of water. Since each cubic foot of this water receives 1,250,000 foot pounds of heat, which must be given off during the autumn months as these lakes gradually settle down to the freezing-point of winter, the amount of heat thus made available for our autumn weather reaches quintillions of foot pounds. This warmth is a break against early autumn frosts. The south side of Lake Minnetonka has most productive vineyards and fruit gardens, while the northern side is liable to early frosts.

Other writers have called attention to the distribution of fresh-water lakes. They are almost wholly confined to the glacial regions of our globe. Northern Europe and northern central North America, with other isolated portions of the globe, are the only places where many bodies of fresh water are found. It remains to be noted that within these glaciated regions the oldest portions are already comparatively free from lakes. The southern border of the glacial area of the United States is almost wholly devoid of them. The vast prairies of Ohio, Indiana, and Illinois have but few, yet there are vast agricultural tracts within these States which show deep and rich accumulations of vegetable mould, evidence of former aquatic plants. Doubtless there were once thousands of lakes within these States, but the silting-in of

mineral debris and the growth of vegetation have filled them up, and thus altered the whole face of the country, a result soon to be very marked within Wisconsin, Minnesota, and the Dakotas. Indeed, the years can almost be counted when glacial lakes within these States will be rare indeed.

The question how long a period of time has elapsed since the retreat of the glacial ice-sheet from the central portion of the North American continent cannot be here discussed. Yet, by way of suggestion, it may be said that, if the filling-up of glacial lake basins be a chronometer useful in measuring geological time, the rate at which these lake basins are now filling up and disappearing, and the fact that they have already disappeared from the southern portions of the glaciated area, are strong presumptive evidence that the ice of the glacial period lingered longest in the region between Lake Michigan and the Missouri River to the north of the 44th parallel, and that here the time since its disappearance has been comparatively brief; indeed, that the estimates of Gilbert, Wright, Winchell, Upham, and others are long enough to explain every phenomenon save, possibly, that of the redistribution of plants.

The two remaining lake types are more permanent. Rivers will continue to be silted and their currents choked so long as two streams of varying transporting power merge into one. Rock basins will continue to hold water so long as the conditions of erosion are unfavorable through the obdurate resistance of crystalline rocks, and plant growth is discouraged through the lack of soil, as is now the case around the margins of the rock-basin lakes of northeastern Minnesota.

THE ROYAL SOCIETY OF CANADA.

THE twelfth annual meeting of the Royal Society of Canada was held at Ottawa, Canada, during the week beginning May 22, and terminated its sessions on Thursday evening, the 25th.

The meeting opened under the presidency of Dr. J. G. Bourinot, C.M.G., clerk of the House of Commons, etc. The meeting was very well attended by fellows and delegates.

The society divides itself into four sections, as follows: I. French Literature and History; II., English Literature and History; III., Mathematical and Chemical Sciences; IV., Geology and Biology.

Amongst the papers which interest the readers of *Science* most were those of Sections III. and IV., besides the "Science Lecture" given to the public under the auspices of the Royal Society in the Assembly Hall of the Provincial Normal School.

The president's inaugural address dealt with "Our Intellectual Strength and Weakness," which received most favorable comment

The public science lecture was delivered by Dr. Ramsay Wright, professor of biology and histology in Toronto University. His subject was, "The Natural History of Cholera." In a masterly manner Professor Wright treated his subject, and described this minute microscopic plant through all its phases and life-history in a simple, clear, and practical manner, throwing a flood of light and giving an amount of information of great value.

In Section IV. Mr. Whiteaves gave the presidential address, in the course of which he summed up the result of researches in the Cretaceous formations of Canada. In the course of his address Mr. Whiteaves showed that in Canada no less than 600 species of fossils were known from the Cretaceous rocks of the Northwest Territories, of the Rocky Mountain region, and of the coast and islands of British Columbia. Of these some 450 were marine invertebrates, mostly shells, and characterized the two divisions into which the Cretaceous system was divided in Canada, viz., the Earlier and Later Cretaceous.

Sir William Dawson had described or identified no less than 115 species of plants from the Nanaimo, Queen Charlotte Islands, and British Columbia Cretaceous basins. Mr. Whiteaves himself had devoted his attention to the invertebrate and vertebrate faunas (*partim*), whilst Professor Cope had in his hands a number of the deinosaurian remains which characterize certain horizons of the Cretaceous in the Prairie region of the Northwest.

Then came Sir William Dawson's paper, entitled "Additional Notes on Cretaceous Plants from Port McNeill, British Columbia." The collection made by Dr. G. M. Dawson at this place was cursorily noticed in a note printed in the Transactions of this Society (1888, p. 71, Sec. IV.). As the collection is large and the specimens unusually perfect, and some of the species are new and very interesting, it has been thought desirable to prepare more detailed descriptions, more especially as these plants belong to either a station or a horizon somewhat distinct from those so familiar in the coal-fields of Nanaimo and Comox on the other side of Vancouver Island.

This paper was followed by another from Mr. Whiteaves, "Description of Some New Species of Fossils from the Trenton Limestone of Manitoba." This was a continuation of two others on the same subject which have already appeared in the Society's Transactions. It contained descriptions and illustrations of several species of Cephalopoda and of one rugose coral.

Dr. Ells then read a most interesting contribution on the geology underlying Northumberland Straits: "The Geology of the Proposed Tunnel under the Northumberland Strait between New Brunswick and Prince Edward Island." The paper discusses briefly the several geological formations which border on that portion of the Gulf of St. Lawrence adjacent to the Strait, with reference more particularly to the several members of the Carboniferous system, the rocks of which have a very considerable development in this area. The proposed tunnel, according to its present location, will traverse these between Cape Tormentine, in New Brunswick, and Carleton Point, in Prince Edward Island, and the description of the strata which will probably be encountered is given, as shown by the series of bore-holes put down during the past season along the line of the principal route.

Dr. Ells was elected fellow of the Royal Society at its last meeting, and has, through his numerous papers and writings on the geology of Canada, contributed much new information regarding the economic minerals, as well as some of the most intricate problems of geology, chiefly in New Brunswick and Quebec.

Mr. Lawrence M. Lambe contributed his second paper on "Sponges from the Pacific Coast of Canada." The paper describes the sponges collected by Dr. G. M. Dawson in the vicinity of Vancouver Island and the Queen Charlotte Islands. There are, all told, about twenty species, seventeen of which are siliceous.

Mr. W. Hague Harrington read a paper on the "Canadian Uroceridæ," in which descriptions, synoptical tables, and lists, together with remarks on the occurrence, distribution, etc., of the species, are given, whilst the Rev. G. W. Taylor of Victoria, B.C., presented "A List of the Land and Fresh-Water Mollusca of Canada, with Notes on their Distribution."

Mr. G. F. Matthew of St. John, New Brunswick, so well known for his valuable papers on Cambrian geology and palæontology, was to the fore with three papers or contributions:—

(*a*) "Illustrations of the Fauna of the St. John Group, No. VIII.," contains descriptions of new species from Band *b* of Division 1, and Band *b*, Division 3; also forms from Division 1 *b*.

(*b*) "On Some Remarkable Organisms of the Silurian and Devonian Rocks of Southern New Brunswick, No. 2." A paper on certain species of the above formations was read before the Royal Society in 1888. The present article contains descriptions of a few others, all of which are from the well-known plant beds of Lancaster, near St. John. These were found by Mr. W. J. Wilson, now of the Geological Survey of Canada. 1. The wing of an insect of the genus Homothetus. 2. A new species of scorpion. This species is of Silurian (Upper) type; the thoracic shield, which is unusually narrow, is the only part certainly known. 3. A new land shell; it resembles *Strophites grandœva* of Sir Wm. Dawson, but is larger and proportionately more slender. 4. A millipede, a minute species, belonging to the division Chilopoda; of which the body is not complete.

(*c*) "Traces of the Ordovician System on the Atlantic Coast." This system has not heretofore been recognized by its fossils on the Atlantic Coast of America, except at St. John, where the oldest part of it (Arenig horizon) is folded in with the Cambrian rocks at St. John. We now recognize it at two other points, viz., Conception Bay, Newfoundland, and Bras d'Or Lake, Cape Breton.